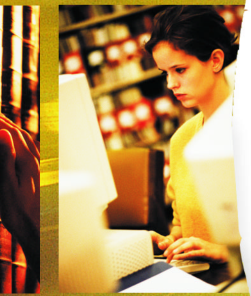
Advanced Engineering Taskforce

Annual Report

September 2001



ILLINOIS CENTURY NETWORK

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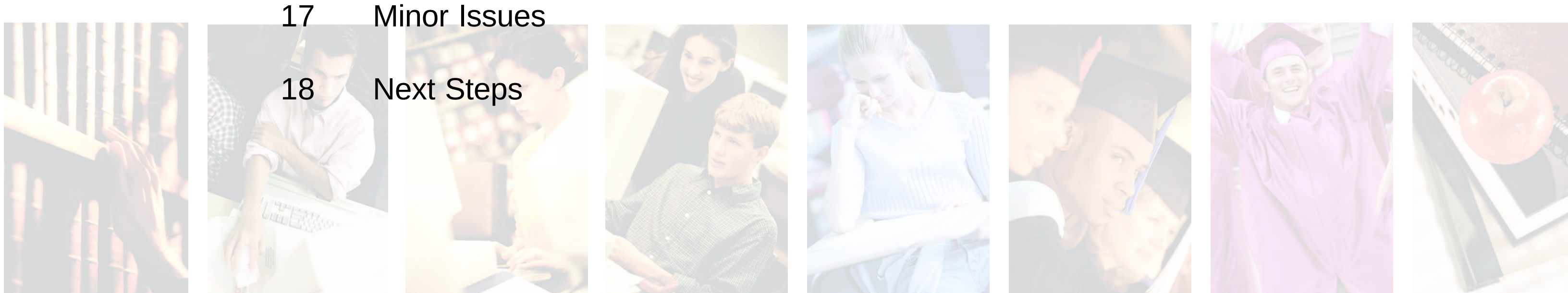

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OVERVIEW

Until recently ICN staff have been working from engineering plans and practices developed as part of the LincOn project and additional work done on behalf of higher education in pursuit of state funding. The funding legislation makes clear that the ICN is to be a single network for all education as well as for other public sector entities. Because K-12 activities were so far along when this additional clientele was added, the influence of prior activities is very strong. There are new challenges for the network's management, related to both the evolution of applications and technology and to changes taking place in the communications industry. To assist the management in navigating these changes, the Advanced Engineering Taskforce (AET) was established approximately one year ago. This report presents our assessment of status and progress, and the most important technical issues facing the ICN in the next two years. An update to this report should be presented one year from now.

The AET consists of a number of individuals from institutions within Illinois which are representative of the clients the ICN serves. Some are from highly technical networking activities while others are more closely aligned with the application areas of greatest importance. In addition, there are several staff members from the ICN staff, CMS, and other agencies who serve as expert sources of information and who participate fully in the discussions. The opinions expressed in this report are those of the institutional representatives and may not be those of the ICN or agency staff members.

STATUS AND PROGRESS

The ICN has been funded as a network since July 1, 1999 although there was previous funding for K-12 schools through the Illinois State Board of Education. For the initial period, plans identified three major initiatives:

(1) Continue the connection of the remaining K-12 institutions,
(2) Greatly expand the capacity of the backbone network and egress to the Internet, and
(3) Connect the new clients such as universities, community colleges, libraries and museums.

Substantial progress has been made on each of these initiatives in the last two years, albeit somewhat unevenly.

Almost all K-12 institutions are now connected to the Internet, with the majority being served by the ICN. Of those connected by other service providers there has been some movement to transfer to the ICN, for a variety of reasons. In most cases these connections are not of sufficient capacity for modern educational applications, which is one of the topics addressed in the report. Nevertheless, the huge volume of traffic generated from this segment of the clientele is prima facie evidence of the significance of the ICN to these clients. While most areas of the state are reasonably served, there are areas where adequate facilities at reasonable prices are not available using current procurement practices. The committee also makes suggestions regarding this topic.

The backbone network has been greatly expanded and there has been excellent provision of capacity in the connections to the full Internet. There have been significant difficulties in implementing this backbone because high-speed circuits are not readily available in all areas of the state, especially using the procurement processes to which the ICN has limited itself. It will be important to continue to upgrade these facilities as traffic grows, and we have several recommendations in this area. The interconnections to the global Internet, frequently called "egress" in our discussions, are one of the primary areas of growth as well as one of the areas where the ICN can offer the greatest value to its clientele. This particular area is characterized by very rapid growth in traffic, but also rapidly falling unit prices. We suggest a specific quantitative plan to keep this Internet access area performing well enough to encourage use and participation in the ICN.

The 1998 engineering recommendations suggested an aggressive plan for connecting institutions of higher education, especially the community colleges. The process of making those connections is nearing completion, although it too has been an area where availability of high speed circuits and the ICN procurement processes have extended the time beyond what seems reasonable. Once completed, it will be important to move ahead more aggressively on updating the video infrastructure of Illinois education, to achieve cost savings on circuits, to allow improved video quality, and to make video instruction available on a much broader basis.

Many of the larger higher education institutions already had well-developed Internet connections and have not participated in the ICN. It is desirable that these institutions work together with the ICN for their mutual benefit.

In summary, there has been great progress toward the goals set in earlier engineering reports and the ICN is nearing completion of an initial network covering all of its clientele. Traffic can be expected to grow dramatically as access to the network is made available to more people and as content supports more educational use. While we do not have detailed data, it seems clear that present use of the network consists primarily of traditional types of general Internet access. This was one of the major goals of the project. A second larger goal is to support inter-institutional traffic and teacher-learner traffic directly related to improving effectiveness of, and access to, education. Moving more of the existing, and new, intrastate video into the ICN environment will be important evidence of meeting this goal. Finally, we do not feel that the level of impact on the digital divide is as large as intended. The most difficult to serve areas, and those with the least financial and technical resources, are still badly underserved. We suggest addressing this by implementing more aggressive steps to achieve good connectivity and by ensuring the availability of basic network services for those who are not self-sufficient.

PROCUREMENT ISSUES AND UNDERSERVED AREAS

It is clear the ICN has had considerable success in building some parts of the state backbone and has experienced much delay in other areas. Areas outside major metropolitan centers, and the poorer areas within them, are not well served by the incumbent local exchange carriers. The dominant interLATA carriers also do not provide adequate services. There are good business reasons why these companies have focused their investments in higher revenue markets, but this leaves an increasing digital divide. The current procurement limitations under which the ICN has been operating serve to reinforce this problem rather than meeting the objective of serving all areas of the state. Not recognizing the competitive nature of the communications market and not looking at all potential vendors and partners will guarantee that the ICN never meets this goal. It also means that the ICN will not gain the best pricing available in the market. It is very unlikely that any master contracting approach will attain the benefits possible under a more aggressive procurement process that reflects the diverse offerings available in different parts of the state.

The ICN should move aggressively to seek services in all geographic areas, bundling its regional purchasing power to make investments more attractive. It should recognize the next generation of requirements discussed below, and incorporate in these negotiations the possible shared use of state controlled fiber to lessen the financial requirements of initiating services in remote areas.

The network backbone is directly provisioned by the ICN, but the local loops are provided to customers who could seek other options. It may be most effective to have regional groups seek services outside state procurement processes if this is the only way to gain relief from the present situation.

EGRESS ISSUES (INTERNET ACCESS)

The general impression is that, despite the immense growth in traffic, the performance perceived at the user level is that the backbone/egress is good. The traffic data we received showed heavy traffic, but reasonable balance across the backbone. It would be worth confirming this general impression by polling the Regional Technology Center (RTC) supervisors. A second impression is that the addition of higher education is generating vast amounts of new traffic, both in the aggregate and from certain specific institutions.

The normal rate of traffic growth for the same group of customers is more than 100% per year. Thus the capacity planned for the start of the school year in the fall should expand by 100% by the end of the school year. It should also be recognized that there will be substantial additional connections and upgrades including some additional community colleges. Experience to date has shown that some organizations with substantial undercapacity go through explosive growth on the first days of upgraded connections. For example, a community college which had a T1 connection, may have been suppressing a traffic demand of 6-8Mb/s, which blooms the moment the pipe is enlarged. The ICN is still in this phase of development.

While few standards exist regarding traffic patterns, there is considerable experience being gathered in the Internet community. Based on this we would expect that the egress needed would be somewhat directly related to the sum of the client capacities connected. Egress demand will fall between five and twenty percent of the aggregate bandwidth of the client connections, or about 35% of actual circuit utilization. Given the growth during a year, trying to keep this around five to ten percent until better data is available seems reasonable. This number will be tempered by the impact of caching and mirroring, and growth of Intranet traffic as a proportion of overall use. Based on a quick estimate of connectivity, ten percent would mean about 600Mb of egress. The backbone is reasonably matched with this after near-term upgrades.

Although the ICN was conceived as both an Intranet (between Illinois institutions) and a means of offering access to the Internet, it seems to be dominated by the second of these at the present time. Whether this will change as more programs are developed and more audio/video capability is utilized remains uncertain. Since the dominant information sources appear to be outside Illinois, or at least off the Intranet, there are several steps that should be taken to better manage the demand for egress. First, the ICN should move immediately to install a high performance cache at one of the egress points. This will allow staff to become familiar with the technology, and generate specific performance data on the impact. An aggressive selection should be made to provide caching for the network. It is possible that vendors would lend test equipment for evaluation, which could eliminate acquisition delays. Assuming success, we should plan on funding a cache at each egress point during the next year. This is one of several areas we suggest obtaining temporary help from institutional staff already familiar with the technology.

A second area of immediate action to reduce egress demand is the use and promotion of mirror sites inside the ICN for popular materials. Examples include various software distributions, both public domain and licensed, and popular information sources such as Britannica. Identifying which solution will have the biggest impact can be determined by measuring the traffic to popular sites.

ICN staff has investigated services to support mirror sites and caching and the AET endorses these efforts.

STANDARDS AND PROTOCOLS

The Internet standards and protocols have been remarkably stable during the past decade allowing equipment and applications to be a mix of old and new. Several generations of equipment are currently in use, but not all of it supports the latest features. While the basic protocols have been stable and consistent with continued use of older products, there has been rapid improvement in the form of new capabilities. Several of these are relevant to the ICN and its client institutions.

It was widely expected that growth and new capabilities would require a major overhaul in the base protocols, going from the current version 4 of TCP/IP to a heavily modified version 6. Various concerns were behind this expectation including growth in the number of connected computers beyond the original design point, and the need to guarantee individual users and institutions consistent performance for applications like video. We fully expected that Internet2 would rapidly move to this set of protocols and the general Internet would follow within a few years. One requirement would have been that backbone networks move early because most features only function if supported end-to-end. Fortunately, the need for this changeover seems to be moving into the distant future and may be replaced by enough incremental changes to avoid a major conversion. At the present time there is no need for the ICN to worry about implementation of IPV6, but rather look at incremental improvements in the form of upgrades. It would be prudent to reserve address space usable in IPV6 ensuring this does not become an issue restricting ICN growth.

There are several new features of the Internet protocols the ICN must seriously look into if it is to provide a competitive backbone. These include multicast, quality of service, and H.323.

Multicast is the capability for a single source to transmit the same material to many individual computers simultaneously without sending a separate stream of data to each. This is the rough counterpart of broadcasting a radio signal to everyone within a geographic area. On the Internet, an example would be that everyone on a campus network receives the material with only one copy transmitted from the point of origin to the campus. Only the local network needs to deal with the multiplicity of copies, and Ethernet handles this effectively. It should be obvious that if lectures are broadcast from a point of origin to many students, or a superintendent wants to speak to all her principals, the traffic can be greatly diminished using multicast. The burden on the network is not reduced unless the receivers are all listening at the same time, similar to a live broadcast.

Quality-of-service is a general set of capabilities related to guaranteeing stability and speed of performance, reserving bandwidth for the duration of a "session" and providing for related attributes of traffic management. Since applications like video require both steady performance and relatively large bandwidth, they will only gravitate to the general Internet if performance requirements can be met. Recent modification to IPV4 priority management of traffic, coupled with reasonable growth in excess bandwidth, is allowing all but the most demanding applications. The ICN backbone is anticipated to be sufficient for these demanding applications, although the committee expresses reservations about the connections between institutions and the backbone.

Quality-of-service, if well implemented, can allow a shared network to provide most of the appearance of a private network. Thus it may be possible for the ICN to meet the demand for private networks between multiple campuses of the same institution through some combination of priority guarantees at the IP level or virtual circuits at the ATM level. To the extent feasible, it is desirable to have as much of the traffic as possible between two points sharing the largest capacity circuit, rather than a multitude of separate smaller circuits. The total capacity needed is lowest in this design, and the network management is simplest. Concerns of redundancy need to be taken into account in applying this principle. H.323, the standard for transmitting video over Internet protocols, is discussed with other video issues.

The switches and routers that implement the ICN need to be upgraded to handle these capabilities, as does the local networking hardware of sites. The ICN will need to educate local network administration about these issues, and should consider this one of the areas where staff expertise can be used to provide consulting services and product recommendations to clients. Those sites expecting to participate in networked education using any form of streaming presentation need to incorporate multicast within a year.

THE FIBER BACKBONE

The State, through the Illinois Department of Transportation (IDOT), is acquiring major physical infrastructure in the form of conduit and fiber along highways. In addition, some municipalities and other governmental units are making similar arrangements. The AET recommends the ICN be given extensive access to this fiber and use it as the basic building block of the network backbone. IDOT should be encouraged to expand these facilities wherever possible, and work with the ICN and CMS to select the most important targets. Even at the present level of planning it is likely that the majority of LATAs (Market Service Areas) will have state controlled facilities within two years. We do not recommend the state construct its own fiber plant except to make critical interconnections, but that it continues the pattern of trading access to right-of-ways for the right to use conduit or dedicated fiber.

There are a number of reasons for suggesting this strategy. First, there is large short-term savings on circuit costs. The high-speed circuits down the spine of the state have annual costs in the millions of dollars, and each upgrade in capacity substantially raises the cost. None of these circuits is licensed at anything approaching the capacity of a dedicated fiber, and this approach limits the cost of upgrading to the investment in terminating electronics (the equipment required to light and connect to the fiber). Since we anticipate at least a 100% per year growth in traffic, this form of cost control is extremely valuable.

A second reason, related to the first, is that the telecom industry tends to price capacity based on multiples of relatively low speed lines, and to delay the reduction of prices as long as possible (rather than reflecting actual underlying costs to provide service). This is particularly true of the dominant telephone companies who have established revenue streams to protect. Since there is not currently an active market for very high-speed circuits, these circuits continue to have artificially high prices. The capacity of a single strand of fiber is currently approximately 80 billion bits per second, while the fastest circuit currently in use by the ICN is 620 million, a factor of over one hundred. Using owned fiber will encourage the ICN to move to state of the art technology and allow it to seek a leadership position in state networks.

The present methodology of the ICN is to lease bandwidth on fiber owned by "facilities based carriers", limiting itself primarily to the traditional telephone companies. This industry is in considerable turmoil because of the deregulation process, the rapid changes in technology underlying communication, and the rapid growth of next generation communications companies. There is frequent failure of companies, occasional consolidation, and considerable uncertainty about the impact of eventual full deregulation. The ICN can substantially reduce its vulnerability to this turmoil by using owned facilities. It can also gain control over what has been a major problem area, significant delays in the delivery of circuits. Delivery under an owned-fiber regime will depend only on the router/switch vendors, who have proven far more responsive than the telecom service providers.

Finally, there is a technical reason for using this approach. Both the electronics that drive the network and the base technology of transmission over fiber are undergoing incredible improvement. The capacity of a strand of fiber has grown by a factor of about 40 to 80 with the first generation of wave division multiplexing, and is expected to grow rapidly for at least several more years. This area of engineering is currently undergoing a faster rate of improvement than even that experienced by the computer chip market.

Several states have invested in building extensive fiber plants. We do not recommend this. The cost of such a fiber plant is very high, with most of the cost incurred in the placement of underground conduit. Given the number of commercial developments of fiber plants we encourage the state to piggyback on that construction and trade rights to a part of the fiber plant for rights of way along the highways. This kind of cooperation with the communications industry can be beneficial to both and can encourage the rapid growth of coverage of the state. The commercial development will be driven by traffic expectations and focused on major cities and traffic corridors. There may be occasions when the ICN can make small investments to encourage going beyond the market driven coverage, and it should consider this on a case-by-case basis.

We do not currently have a recommendation on whether the ICN should attempt to operate this fiber itself or should contract the operation and maintenance to a facilities-based carrier. What is important is that the ICN have control of the level of switching and routing equipment that is attached, and that its costs not be based on any measure of utilization.

This state asset offers the ICN the opportunity to keep the backbone portion of its network ahead of demand, and to do so at a cost well below any other alternative. Care should be exercised that it is possible to replace the fiber in the conduits at some future date, as this is still an area of active engineering. One approach to this is to obtain the right to some amount of conduit space along with an initial complement of strands.

K-12 NETWORK REQUIREMENTS

The AET has great concerns about the level of capacity currently provided to primary and secondary schools. In most cases it is not sufficient to provide the applications that will allow the schools to exploit educational materials. While it is probably true that many schools are not currently using all of their capacity, this may be because the applications they see are not sufficiently compelling. The ICN should inform school districts and ISBE of the anticipated growth in demand and associated costs. It should also begin a process of working through the RTCs on the process of acquiring favorable arrangements for district network upgrades.

EDUCATIONAL PERFORMANCE REQUIREMENTS

In looking at performance requirements it is useful to first look at an individual user and then at the aggregation of users at a given site - i.e. sharing the same link to the backbone. An individual can easily view text using a good modem, or a 30-56kb/s link. Once a user moves to viewing several still pictures the requirements go up because extensive delays waiting for the picture to be delivered loses the users attention. If the user decides to wait, the computer is tied up and not usable by others. Thus, the number of computers needed for a group of students is greatly increased while the quality of the service is unsatisfactory.

Good presentation of still pictures can be done with speeds of 100-200kb/s, so long as they are not high resolution. A picture equivalent to a Kodak CD of 35mm pictures can be transmitted in a few seconds. Once you go beyond still pictures the requirements go up considerably depending on the quality desired.

Small live video sequences can be shown with very few frames per second at speeds below 200kb/s, but the equivalent of the video instruction network requires about 400kb/s. At this speed the picture will have the familiar jerkiness and discontinuity if there is any significant motion portrayed.

At about 1.5Mb/s (T1) the picture quality begins to resemble something that one would willingly watch for an extended period, but is nothing like the quality of a home television set. If useful educational materials are to be presented, lectures can be transmitted in the 400kb/s range, but other materials with either more motion or additional requirements for accurately presenting a complex picture, will need at least the T1 level. Newer video approaches utilizing MPEG2 encoding are likely to require 4-6Mb/s for more complex materials with a lot of motion and where color differentiation makes a major difference.

An alternative way of looking at this is that using the full capabilities of streaming and compression, a small picture with reasonable amounts of motion can be well supported by about 250kb/s and a 10 inch picture by about 400kb/s. The level of detail and the amount of motion determine the actual perception of quality, and advocates of video tend to want more bandwidth for the associated improvements in quality.

We recommend that the network be engineered to present the individual user burst capacity of at least 1Mb/s, and that this be made available to all high schools within two years. To achieve this the schools will likely need to be connected at 10Mb/s or higher depending on the actual number of concurrent users of video materials, and the duration of viewing. In cases where there is frequently used material it will be desirable to move those materials onto servers on the school Local Area Network (LAN) rather than receiving it over the Wide Area Network (WAN). We anticipate this requirement will move into the primary schools, and that the expectations of quality presentation will be even higher among this group whose expectations are set by television and electronic games.

The picture for the individual user is fairly straightforward. Analysis gets much more complex in dealing with attaching a multi-user site to the backbone. If all users are dealing with text rather than graphical or audio/video content, their requests for material to be transmitted are infrequent, relatively short in service duration, and not particularly sensitive to uneven rates of transmission. Experience has shown that a link to the outside at T1 (1.5 Mb/s) can service approximately 50 such concurrent users.

Still pictures are also infrequent, somewhat longer in transmission, and not very sensitive to relatively uneven delivery rates. The major impact of adding this type of material is to reduce the number of concurrent users by perhaps half to two thirds, since larger blocks of time are needed to fill a screen. Having too many users simply degrades the feeling that the network is responsive, but still allows work to proceed.

Moving pictures are much more demanding in all aspects. The request can be for pre-stored (previously recorded) or live broadcast material and is continuous for a period of time ranging from a few seconds for a video clip to the duration of a live class. During transmission, the user is quite sensitive to uneven transmission - i.e. a jerky presentation. The transmission must be given claim to its required bandwidth or the presentation is useless. The impact on other users is pronounced unless there is sufficient total bandwidth, and there is a high likelihood of several users wanting service concurrently. There are various partially satisfactory approaches to this problem, in addition to providing adequate bandwidth. If it is possible to send the material ahead so that it is stored at the site, local network capacity determines the quality but with the loss of real time interaction. There is also a developing capability to give one user priority over others, which can take care of the priority users at the expense of others. It is also possible to put in a second circuit and allocate its bandwidth to specific stations, such as in a particular classroom. These alternatives may be acceptable stopgaps, but they are not sufficient to stimulate the growth of educational applications.

Finally, we point out that sound is very demanding on steady performance, although not particularly demanding on average. Human speech can be adequately transmitted at about 10kb/s and CD quality sound at 100kb/s or less, but any fluctuation in the presentation is very disconcerting. Since sound is an essential part of most educational material, it is important to ensure adequate capacity to maintain sound quality.

Each site will need to be matched to the capacity required for its users' applications. In any case where there is an expectation of several students concurrently using remote educational material, including participating in distant classes, it will be necessary to upgrade to at least multiple T1 circuits, and rapidly beyond this. While telecom industry offerings don't necessarily present any alternatives between T1 and T3 (45Mb/s at perhaps 15 times the price of a T1), there are numerous other approaches such as using local cable TV. The ICN should begin working with any schools that plan to be active in programs such as the Virtual High School to ensure adequate performance as bandwidth demands increase, and thus encourage the development of educationally attractive materials. There is nothing more frustrating to faculty developers than to have materials that cannot be effectively delivered because of network inadequacy. It should be noted that if a group of schools (such as a district) has a good local network between buildings, only one high-speed link to the ICN backbone is necessary. In many areas, facilities outside the telecom industry are available at speeds between T1 and T3.

What is discussed above relates to the communications to the local site LAN. Many schools do not have the internal LAN capacity to deal with this volume of traffic, and will need to make improvements as well as potentially adding servers. This is an area where the ICN regional staff, or the hosting institution could provide valuable consulting services.

VIDEO ISSUES

As mentioned several times before, video in its many forms is likely to be the driving force in traffic growth. Video is becoming an increasingly important form of networked education. Video includes a variety of approaches, from live distribution of lectures to pre-stored material that can be viewed on demand. The emerging availability of very low cost cameras for attachment to PCs and even palmtop devices will allow personal communication that includes audio and video. This is a radically different picture than just a few years ago when Illinois invested heavily in video equipment at many institutions of higher education to create the Illinois Video Education Network (IVEN). Currently, IVEN consists of over 450 sites within 10 consortia throughout the state. Most of the sites are using dedicated T-1 circuits with H.320 technology. In addition to all of the technological advances and cost reductions in video, there has been rapid movement toward using Internet distribution rather than the current dedicated telephone circuits. The primary element of this is the H.323 protocol being implemented over the TCP/IP standards. The rapid growth of high-speed connections has allowed this form of traffic to be carried on networks like the ICN. Several IVEN sites have already converted to H.323.

The original investment has created an ability for many institutions to originate video instruction, and the investment in those origination classrooms and studios still has considerable value. Because of the use of circuits dedicated to this use, the audience is currently limited to a relatively small number of sites, primarily at community colleges and a few high schools. The potential is now there to open up delivery to every desktop computer with reasonable network attachments. This can greatly increase the potential of networked education to serve advanced placement students and others who wish to take courses originating at distant sites. The addition of highly affordable cameras can also make possible personal live video communication from a distant student to the instructor. This level of participation can overcome many of the disadvantages of previous video instruction.

The AET feels the ICN should take the following steps to take advantage of this new video alternative:

(1) Interconnect the current educational video network to the ICN using H.323 so every desktop computer becomes a potential delivery site.
(2) Convert existing T1 video circuits to ICN tariffs as sites convert to H.323.
(3) Inform schools of this new alternative and promote projects to stimulate use.

(4) Offer consulting services to organizations which want to offer video servers for instructional material and promote an infrastructure that supports logistical needs such as scheduling.

(5) Move aggressively to incorporate multicast capabilities so that traffic presented to the backbone is managed efficiently.

We do not feel that it is worthwhile for the ICN to attempt to provide dedicated circuit replacements within the existing T3 lines to the community colleges, but rather it should take steps to accelerate the transition of this traffic to H.323 rather than H.320. The savings on circuit costs can be gained in this way, and in many cases, the quality of the video picture can be greatly increased with minimal cost. The ICN, or other state funding, may be required to replace the equipment connecting the video site to the telephone network with H.323 equipment. The equipment can be upgraded for a fraction of the original cost. This is a good investment, and protects the past use of state funds. We anticipate this step will also increase the relatively low utilization of the video networks because it will open up the alternative to many students scattered at individual sites allowing participation. This technology will break down the current limitations where high schools are really only connected to a single originating college and will allow instruction from anywhere on the Internet rather than just from within Illinois' video consortia.

MEASUREMENT ISSUES

At the present time there is a minimal level of measurement tracking the performance and use of the network. It is critical that this be addressed on two fronts. First, it is important to be able to provide funding agencies evidence that the network is used, not excessive in capacity, and performing reliably. It is also important to provide this group with some evidence that the use is meeting the intentions of assisting educational programs. The second type of measurement program is to gather the data necessary for managing the network and the upgrading of equipment and circuits. We hope that a substantial program of measurement for both of these objectives will be undertaken in the very near future.

One area for immediate action is instituting basic traffic analysis at two points in the network. The first of these is at the egress point, and the second is at the interconnection of the heaviest traffic institutions with the ICN. At the egress point it is relatively easy to use the router's capability to provide data on source and destination. Thus we can identify where the traffic is going. This will require some recording capability and some staff effort for both setup and analysis. Again this is an area where temporary assistance from people with this precise experience can assist the staff to move more quickly. Alternatively the ICN could contract with one of the experienced networking groups at the universities to conduct the measurement program. This effort can also help analyze one of the unexpected features of the data provided to the AET, the near equality of outbound traffic with inbound. We would have expected this network to be dominated by clients (inbound) rather than servers (outbound). It is likely that this phenomenon is due to things like music serving from resident students, which may be outside the intended scope of ICN funding. Before this can be addressed on a policy level there should be some data on the scale of the problem. Data on types of use can more easily be captured at the user site than at the egress point, and since the largest users probably dominate traffic, this should be relatively useful. In a brief review, universities were mentioned as having large impacts on traffic as they joined the ICN. There is some capability at the RTCs to measure traffic of their community college clients. This should be in place by the opening of school.

The impact of mirroring and server installations can also be determined and demonstrate the efficiencies gained by ICN members working together.

In addition to routine use to monitor network routing, scripts can be created and used after any major change in routing to verify there are no unanticipated results from the changes.

All of what is outlined above is aimed at the current and near-term situation. There do not appear to be immediate serious problems, but given the rate of growth in connectivity and demand and the rapid adjustment of expectations to ever-higher levels, we can serve the community well by being prepared.

Measurements to demonstrate the educational value of the investment in the ICN are somewhat more complex. Some indication of value will come from seeing the volume of Intranet traffic versus Internet, since this is traffic between Illinois institutions. More refined measurement can show the type of application, and indications of increased video traffic within the Intranet would indicate more use in distance education, as well as be useful in determining the timing of requirements to increase capacity. Traffic to known educational resources such as Britannica or ISBE servers are also indications of meeting the objectives of the state funding.

PROMOTING CONTENT

The AET is focused on the engineering and technical issues of the network. What justifies the network, however, is the set of applications and content made available to the clients. We would like to see more done by the ICN and the sponsoring agencies to promote the use and development of materials of educational value. To achieve this requires the improvements in network performance that we have suggested, but also requires more training of teachers and school librarians, more licensing of materials, and more assistance to the faculty and local systems support staff in the schools and colleges.

At some time in the near future the ICN should sponsor a joint meeting of the AET, ICN technical staff, and any content related groups to discuss barriers to progress, and to share knowledge about issues.

SERVICES

The value of the network is in the applications and information which users gain access to. There are a number of generic applications that every user will need in the course of their educational use, including such things as access to web - based materials, course management applications, email and discussion systems. Instructors need access to servers for web-based materials they develop and can gain great advantage from course management aids, once the material is ready for general use. Unfortunately the institutions most in need of assistance getting involved in networked education are the same ones which are unlikely to have funding and capable technical staff to provide such facilities. The AET discussed whether the ICN should get into the business of providing these services for those who need them, and trying to ensure universal availability of a basic set of services. It was the feeling of the group that the ICN should not get into this aspect of the business, and should instead concentrate on the provisioning of basic network infrastructure.

The reasons we feel that the ICN should not get into this area relate to the difficulty of scaling such services to the whole state, the manpower requirements to handle large numbers of beginning users, and the availability of alternative approaches. We do encourage the RTCs to work with local clientele to arrange such services. The RTC hosts may wish to provide such services on a cost recovery basis.

While suggesting that the ICN not provide such services, we recognize that it is important to help achieve universal availability of these basic services. We suggest the ICN, either centrally or via its RTC organizations, provide a consultation service to those wishing to establish such services for themselves or via a consortium. This service should be provided at least partially on a cost recovery basis. If there is a project to seriously address the issues of the digital divide, funding should be included to ensure availability of both consultation and services for those needing assistance getting started.

(Note: Digital-divide is a term covering all aspects of citizens not having access to technology, whether because of geography, language, income, age or prior education.)

MINOR ISSUES

One area where the ICN can be of particular value to its constituents is in serving as an intermediary with advanced projects such as Internet2, MREN and some of the video initiatives. Some particularly valuable applications have been developed which require significantly higher performance networking than that which is generally available to the ICN community. The ICN should undertake, perhaps with partners in related high performance networking communities, reasonable means to enable the implementation of these types of applications and network capabilities. Often these initiatives are early examples of capabilities that will be widely deployed in future years and can serve as a foundation for future statewide educational networks.

Other opportunities are likely to arise for cooperation with networks servicing nearby states, and the ICN should work with these groups to promote mutual benefits. Because of the central role the Chicago area plays in the physical infrastructure of the telecommunications and Internet industry this presents a unique opportunity for Illinois to play a leadership role in both national and international communications.

NEXT STEPS

The AET should move to a schedule that ties more closely to the budget preparation and related hearings. Over the next few years it will be important to develop financial models which allow the ICN to encourage good public policy directions in bridging the digital divide and involving the Illinois public sector forward. The state funding of this network is far too small to cover all costs, but certainly large enough to give incentives for cooperative approaches and to subsidize, where necessary, for public purposes.

Issues concerning community networks will continue to be important, and are an area where an independent review body can help develop policies consistent with normal practices by publicly funded networks.

This report does not exhaustively identify all required communications technologies, which are currently undergoing rapid change. Such an undertaking would have been beyond the scope of the Taskforce's charter. Consequently, only a select number of key topics were explored. However, the Taskforce recommends that the ICN have an on-going process for evaluating, testing, and deploying appropriate new technologies as they become available. The Taskforce welcomes cases where the staff feels an issue needs outside consideration and will add it to our agenda.

Printed by Authority of the State of Illinois
September 2001

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